

REMARKS

Claims 1-13 are pending in the application. Claims 1-8 are rejected and claims 9-13 have been withdrawn from consideration.

Claims 1-8 are rejected under 35 U.S.C. § 103 for being unpatentable over U.S. patent application publication no. 2002/0000552 (referred to as “Morimoto”) in view of U.S. patent application publication no. 2004/0137158 (referred to as “Kools”).

With regard to independent claim 1, the Office Action indicates that:

- (1) Morimoto teaches all that is claimed except for the use of a gas cluster ion beam;
- (2) Kools:
 - (a) teaches methods using monomer and cluster ion beams,
 - (b) “depicts in fig. 6 the cluster ion beam smoothing at an acute angle,” and
 - (c) “recognizes the equivalency of an Ar monomer beam and Ar cluster beam in the field of angled smoothing of a substrate”;
- (3) it would have been obvious to replace the Ar monomer beam of Morimoto with the Ar cluster ion beam of Kools because:
 - (a) “it is merely the selection of functionally equivalent angled smoothing recognized in the art “
 - (b) “one of ordinary skill would have a reasonable expectation of success in doing so”; and
- (4) “... since both [Morimoto and Kools] teach methods (i.e., monomer beam and cluster ion beam) for angled smoothing of a substrate, it would have been obvious ... to substitute one method for the other to achieve the smoothing of a substrate surface.

The Applicants disagree with assertions (2) through (4) and respectfully submit that these assertions are not supported by the prior art but instead are contradicted by the prior art.

Assertion (2)

The Applicants agree that Kools discloses the use of monomer ion beams and gas cluster ion beams for smoothing; however, they disagree that Kools discloses the use of gas cluster ion beams at acute angles and they disagree that Kools recognizes these two beams as being equivalent.

gas cluster ion beams at acute angles

Referring to paragraphs [0061] to [0066], Kools discloses the use of a monomer ion beam in which the energy of the beam and the angle of incidence onto a substrate to polish or smooth may be set within a range of angles.

Referring to paragraphs [0067] to [0069], Kools discloses the user of a gas cluster ion beam (GCIB) in which the energy of the beam may be adjusted but only one angle of incidence is disclosed, which is perpendicular or normal to the substrate (see last sentence of paragraph [0069]).

Contrary to what is asserted in the Office Action, Kools does not disclose cluster ion beam smoothing at an acute angle. The Office Action refers to Fig. 6 for support of this assertion but the Kools indicates Fig. 6 illustrates “one embodiment of the smoothing step” in which “particles 208” bombard a surface. In view of what is disclosed in the specification, the angle illustrated in Fig. 6 for the one embodiment can pertain only to a monomer ion beam.

This conclusion is consistent with other prior art that is cited in Kools and was disclosed previously in Information Disclosure Statements. Referring to paragraph [0068], Kools cites U.S. patent 5,459,326 to Yamada et al. and U.S. patent 6,375,790 to Fenner et al. Referring to cols. 3 and 4 in Fenner et al.:

“... At that focus point on the beam axis the workpiece target 104 is located, it being perpendicular to the beam.” (col. 3 lns. 49-51)

“... an optical method of measurement is utilized, since it can do so while working well away from the normal incidence angle that the cluster beam requires” (col. 4 lns. 20-23)

As may be seen, Fenner expressly teaches a normal incidence and further indicates it is required.

The Yamada patent also teaches using a normal incidence. The inventor expounds upon this teaching in a paper previously disclosed by the Applicants in an Information Disclosure Statement. This paper is discussed below.

gas cluster ion beams and monomer ion beams are equivalent

With regard to the assertion of equivalence, the Applicants respectfully submit that Kools does not disclose or suggest that monomer ion beams and GCIB are equivalent. The prior art teaches the opposite.

Referring to paragraph [0069], Kools cites “Substrate smoothing using gas cluster ion beam processing,” Journal of Electronic Materials, vol. 30, no. 7, Jul 2001, p.829 by Allen et al. (A copy of the text from this paper may be obtained from:

http://findarticles.com/p/articles/mi_qa3776/is_200107/ai_n8964633.

Referring to the first paragraph under the heading “Gas Cluster Formation,” Allen et al. state the following:

“The impact morphology and kinetics of an atomic or molecular cluster ion impinging on the surface is quite different from that of an ion implanted atom into a target.”

This statement is consistent with statements made in the Yamada paper discussed below.

The Applicants respectfully submit that, contrary to what is asserted in the Office Action, the prior art does not recognize an equivalence between monomer ion beams and gas cluster ion beams. Instead, the prior art recognizes they are “quite different.”

Assertion (3)

As explained above, monomer ion beams and gas cluster ion beams are not functionally equivalent. As a result, a person of ordinary skill in the art would not have a reasonable expectation of success from substituting one technique for another. The energy levels, incidence angles and smoothing effect of the two techniques are very different as explained by Yamada.

Yamada, “Cluster ion beam process technology – 20 years of R&D history,” Nuclear Instruments and Methods in Physics Research, B257, 2007, pp.632-638, which was disclosed previously in an Information Disclosure Statement, states the following:

“The interaction effects are very different for monomer ions, molecular ions and very large clusters.”

“An important characteristic of large gas cluster ion bombardment is an effect known as lateral sputtering. Angular distributions of surface atoms ejected by cluster ions are considerably different from the distributions produced by monomer ions.”

* * *

“Lateral sputtering produces surface smoothing behavior which does not occur with monomer ions.” (pp. 635-636)

Referring to the graphs and text on page 636, the Yamada paper shows surface smoothing for gas cluster ion beams decreases (roughness increases) as the incidence angle increases from zero degrees (normal incidence) to sixty degrees. In contrast to this, Yamada teaches that surface roughness increases for monomer ion beams with normal incidence.

The Applicants believe these statements are sufficient to show monomer ion beams and gas cluster ion beams are not functionally equivalent and that a person with ordinary skill in the art would not have had a reasonable expectation of success in substituting one for the other.

Assertion (4)

For reasons discussed above, the Applicants submit it would not have been obvious to a person having ordinary skill in the art to substitute a gas cluster ion beam for a monomer ion beam.

The Yamada paper indicates that smoothing decreases (surface roughness increases) monotonically as the incidence angle increases from normal to sixty degrees. The paper does not provide any data for incidence angles greater than sixty degrees. In absence of any further teaching, persons of ordinary skill in the art had believed that smoothing performance of gas cluster ion beams continues to degrade as the angle of incidence increases beyond sixty degrees.

Contrary to what was suggested by the prior art and understood by those having ordinary skill, the Applicants discovered that improved smoothing could be achieved with gas cluster ion beams at incidence angles greater than sixty degrees. The Applicants respectfully submit that doing something contrary to what the prior art teaches is the antithesis of obviousness.

To err on the side of caution, the Applicants wish to point out that the claims recite the angle between the surface and the beam, which is complementary to the angles discussed in Yamada that are expressed relative to normal incidence. As a result, the claims refer to angles that are less than thirty degrees.

Dependent Claims

The remaining claims depend on claim 1 and add further limitations to features that are not disclosed or suggested in either Morimoto or Kools.

CONCLUSION

The Applicants request reconsideration in view of the discussion set forth above.

Respectfully submitted,



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